DEPARTMENT OF MINES AND AGRICULTURE.

MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

E. F. PITTMAN, A.R.S.M., GOVERNMENT GEOLOGIST.

PALÆONTOLOGY, No. 9.

THE FOSSIL FISHES

OF THE

TALBRAGAR BEDS (JURASSIC?),

BY

ARTHUR SMITH WOODWARD, F.L.S.,
Assistant Keeper of the Department of Geology, British Museum (Natural History), London;

WITH

A NOTE ON THEIR STRATIGRAPHICAL RELATIONS;

BY

T. W. E. DAVID, B.A., F.G.S.,
Professor of Geology, Sydney University;

AND

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MEMOIR.

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Geological Survey Branch,
Department of Mines and Agriculture,
Sydney, 14 August, 1895.

Sir,

I have the honour to submit for publication Memoir No. 9 of the *Palæontological Series* of the Geological Survey of New South Wales, on the *Fossil Fishes of the Talbragar Fish Beds*, Parish of Bligh, County of Bligh, by Mr. Arthur Smith Woodward, F.G.S., of the Geological Department of the British Museum.

Mr. Arthur Lowe, of Wilbertree, was the first to discover these interesting Fish Beds, and he communicated his discovery to Mr. C. S. Wilkinson, F.G.S., the late Government Geologist, who thereupon instructed Mr. Cullen, the fossil collector, to proceed to the locality. A large collection of fossil fish and plants, together with the remains of one insect, was thus obtained. The fish were despatched to the British Museum, Mr. A. S. Woodward, of that Institution, having generously undertaken to describe them. The thanks of the Department are due to Mr. Woodward for the time and labour he has devoted to this valuable work.

The manuscript of the Memoir reached me early in the present year, and I then learned that Mr. Woodward regarded the fossil fish as probably of Jurassic age. No rocks of this age had previously been recognised in New South Wales, and as no definite conclusions had been arrived at as to the stratigraphical relations of the Talbragar Fish Beds, prior to the receipt of Mr. Woodward's Memoir, I decided to stay the publication of the latter until I had had an opportunity of making a geological examination of the surrounding country.

Professor David, of the Sydney University, having kindly offered his valuable aid, we proceeded together to the locality last Easter, and a note embodying the results of our examination is appended hereto. We found that the stratigraphical evidence is in favour of the conclusion previously arrived at, on palæontological grounds, by Mr. Woodward.

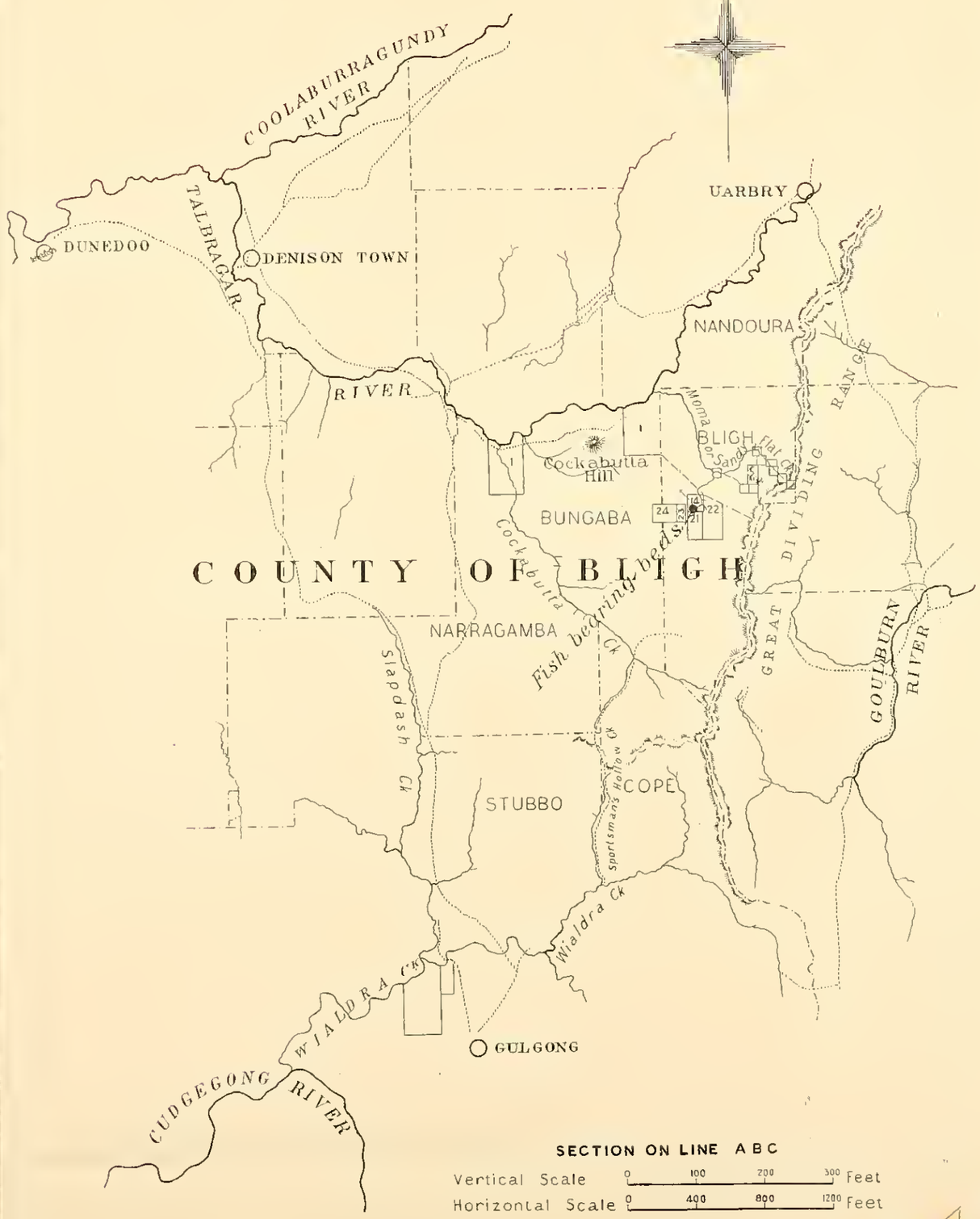
Special interest attaches to this Memoir by reason of the fact that it deals with organic remains belonging to a geological period not hitherto known to be represented in New South Wales.

I have the honour to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN, A.R.S.M.,
Government Geologist.

Harrie Wood, J.P., Esq.,
Under Secretary for Mines and Agriculture.

LOCALITY PLAN

Scale of Miles
0 1 2 3 4 5 6 7 8



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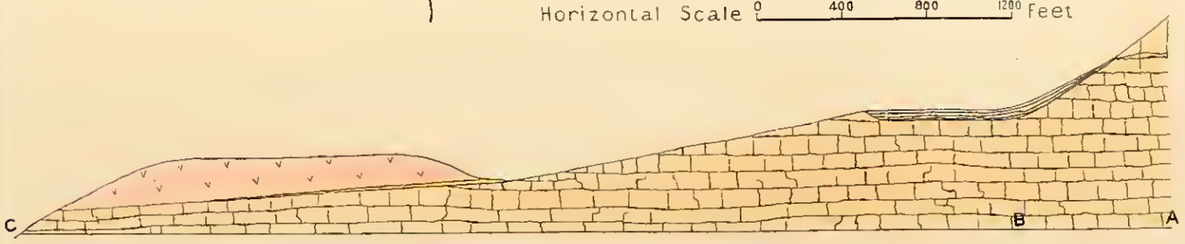

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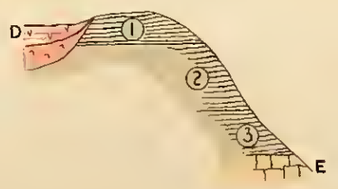

GEOLOGICAL SKETCH MAP AND SECTIONS OF THE TALBRAGAR FISH BEARING BEDS

Scale of Chains
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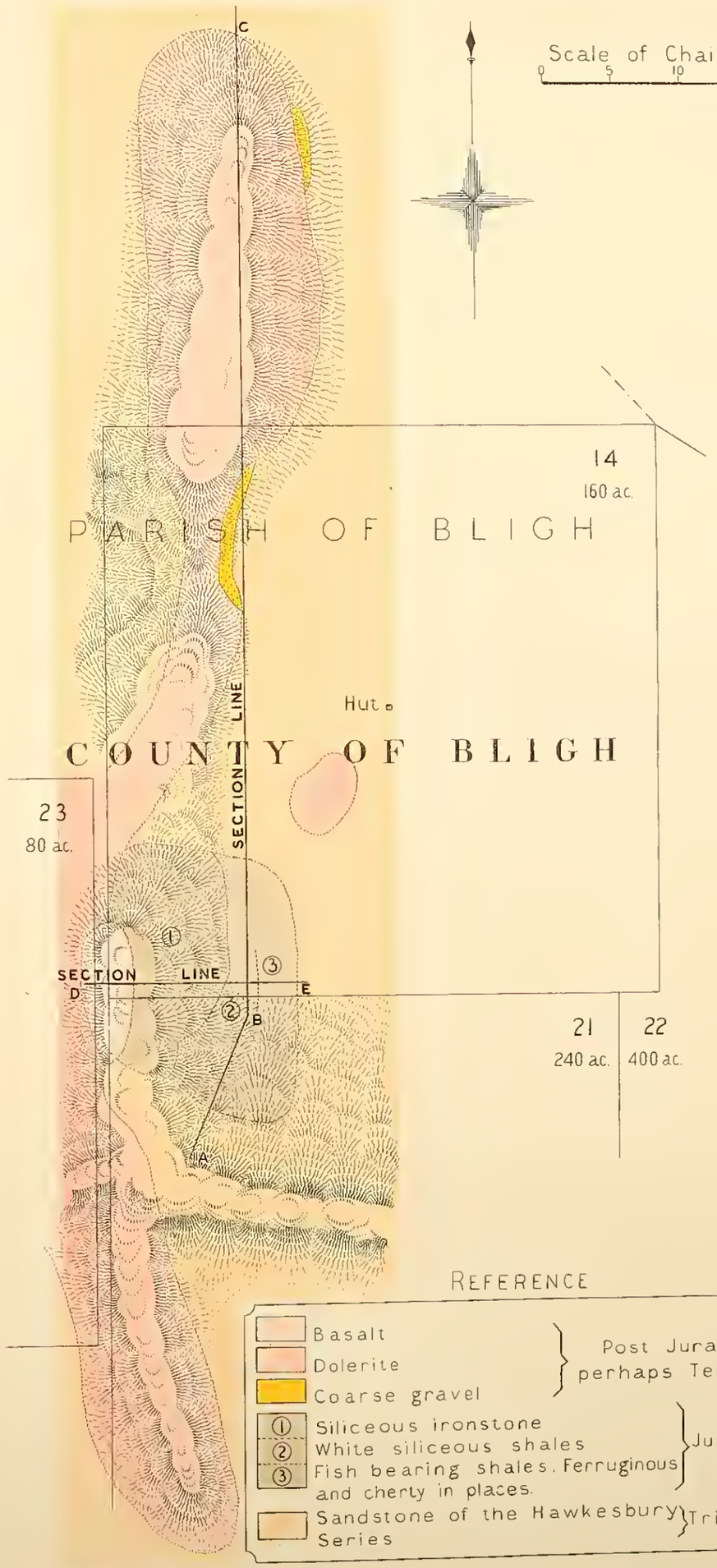

REFERENCE

Basalt, Dolerite, Coarse gravel	Post Jurassic perhaps Tertiary
① Siliceous ironstone ② White siliceous shales ③ Fish bearing shales. Ferruginous and cherty in places.	Jurassic (?)
Sandstone of the Hawkesbury Series	Triassic (?)

(Sig 11a 71.95.)

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

NOTE ON THE STRATIGRAPHY OF THE FISH-BEARING BEDS OF THE TALBRAGAR RIVER.

On receipt of the manuscript and plates of the accompanying Memoir by Mr. A. S. Woodward, and while it was in the printer's hands, we decided to visit the locality where the fossils were obtained with a view of determining their geological horizon. As stated by Mr. Woodward in the introductory part of this Memoir, Mr. William Anderson, late of the Geological Survey of New South Wales, was unable at the time of his visit to arrive at a definite opinion on this subject, though at the conclusion of his paper[1] he states: "I am inclined to think that what little stratigraphical evidence there is points to the conclusion that they form an isolated lenticular patch in the horizontally bedded sandstones similar to the lenticular beds of grey shale which occur in the Hawkesbury Sandstone near the coast." He therefore infers that they may be of Hawkesbury or Triassic age, and consequently perhaps homotaxial with the fish-bearing horizon at Gosford, between Sydney and Newcastle. We accordingly spent several days last April in making a geological examination of the immediate site of the discovery, as well as of the surrounding country, and the results are given in this note, and are illustrated in the accompanying sketch map and sections.

Near Gulgong the older rocks are chiefly argillites and felspathic quartzites, perhaps of Silurian age, intruded by granites and diorites. Between Gulgong and Cockabutta Mountain the country for about the first ten miles is flat or slightly undulating, the superficial deposits being chiefly Post-Tertiary sediments with an occasional sheet of Pliocene basalt. Low hills of granite succeed, and the road gradually rises until at "Barney's Reef," about thirteen miles from Gulgong, dark grey carbonaceous shales outcrop, dipping at a high angle. Impressions of *Vertebraria* are abundant in these shales, proving them to belong to the Permo-Carboniferous System, and probably to the Upper Coal Measures (Newcastle Series). Their high inclination is most likely due to local faulting, as elsewhere in the district the Permo-Carboniferous rocks are seen to be only slightly inclined. At about eighteen miles northerly from

[1] W. Anderson, "On the Stratigraphical Position of the Fish and Plant-bearing Beds on the Talbragar River, Cassilis District, N. S. Wales," Records Geol. Survey N. S. Wales, 1889, I, pp. 137–139, pl. XIV.

Gulgong, on the left bank of the Talbragar River, and about a mile southerly from Meruthera Old Station, the road passes over a decomposed quartz-felsite, showing well-marked fluxion structure, and probably a devitrified rhyolite. From here to Cockabutta Mountain, which lies about five miles to the east, the predominant rocks are massive greyish-white gritty sandstones, current-bedded and pebbly, and ferruginous conglomerates. These rocks appear to form part of a conformable series, which, for reasons to be presently adduced, may be regarded as of Hawkesbury (Triassic) age. Cockabutta Mountain is formed of these rocks. Thick-bedded sandstones in the upper part of this series constitute a well-marked horizon, extending uninterruptedly from Cockabutta Mountain to the Fish Beds, and forming the higher portions of the surrounding flat-topped hills. These sandstones weather into hollow turret-shaped masses, as shown in the accompanying photograph.

Traced to a point about three miles south-east of Cockabutta Mountain the sandstones are seen to pass upwards into a bed of hard red ferruginous shale, about a foot in thickness, containing numerous impressions of fossil plants. Amongst these the following have been identified by Mr. W. S. Dun, Assistant Palæontologist :—

Tæniopteris?
Alethopteris australis, Morris.
Thinnfeldia odontopteroides, Morris.
Thinnfeldia, sp.
Phyllopteris Feistmanteli, Eth. fil.?
Sphenopteris, sp.
Detached leaves referable to *Baiera* or an allied plant most probably.

One of the most characteristic fossils in this bed is a plant referred to *Tæniopteris?* with a "goffered" margin, such as may be often seen in the young fronds of living ferns like the hart's-tongue, &c. This peculiarity was not observed by us in the fronds of *T. Daintreei* obtained from the Fish Beds. As no trace of the venation was preserved in the specimens from the former locality, it is of course possible that the fossils may yet prove to belong to some species other than *Tæniopteris Daintreei*.

This bed caps a low flat-topped hill, so that no evidence was obtainable as to the nature of the strata which once overlay it, but from the fact of there being a gradual transition at its base into the underlying sandstone, taken in conjunction with its lithological character, which is of a type common in the shale beds of the lower portion of the Hawkesbury Series,

Photographed by Professor David.

View at Cockabutta Mountain, Talbragar River, showing weathering of sandstone rocks of the Hawkesbury Series.

there is good reason for assuming that it belongs to the above series. The thick-bedded sandstones were followed by us continuously from here to Boyce's Selection (Portion 14, Parish of Bligh, County of Bligh), where they form the strata which immediately underlie the Fish Beds.

The Fish Beds proper form the lowest of the three members into which, on lithological grounds, the deposit to which they belong may be divided. They consist of laminated, hard, siliceous shales, cherty in places, rendered ochreous by ferruginous infiltrations, and traversed by joints. Their bedding is almost horizontal, as far as can be judged from their line of outcrop, which can be traced for about ten chains. Their exact thickness was not observable, but appeared to be about ten feet. Fish and plants are so abundant that it is difficult to find even a small fragment of the shale devoid of them. The plants are preserved in the form of siliceous impressions, their pure white colour contrasting strongly with the ochreous tint of the enclosing shale.

In addition to the fish described by Mr. Woodward in this Memoir we obtained the following plants, which have been determined by Mr. W. S. Dun:—

Teniopteris Daintreei, McCoy.
Podozamites lanceolatus, Lind. and Hutt.
Thinnfeldia odontopteroides, Morris.
Thinnfeldia, *sp.*
Taxites [*cf. T. planus*, Feistmantel, *Pal. Indica*, *II* (12), *t.* 2, *f.* 9–10].
Neuropteridium australe, Ten.-Woods ?
Sphenopteris, *sp.*

The species of most frequent occurrence amongst the above plants was *Podozamites lanceolatus*, which was not observed to be represented at all in the bed of red shale described previously.

The *Teniopteris Daintreei* found in the Fish Beds showed the characteristic venation and perfectly flat fronds with no trace of the "goffering" along their margins, so characteristic of those provisionally referred to the same genus from the red shales. Amongst the specimens formerly collected from the Fish Beds by Mr. C. Cullen, Mr. Robt. Etheridge, Junior, determined the following species:—

Thinnfeldia odontopteroides, Morris.
Teniopteris Daintreei, McCoy.
Podozamites lanceolatus, Lind. and Hutt.
Podozamites spathulatus, Feistmantel.
Podozamites longifolius, McCoy ?
Podozamites, *sp.*

In a preliminary report[1] on the above plants Mr. R. Etheridge, Junior, discusses the evidence which they supply as to the stratigraphical horizon of the Fish Beds, and concludes *provisionally* that the latter are probably the equivalents of the Bellarine Series of Victoria and the Ipswich Series of Queensland, with relations to the Clarence Series of N. S. Wales.

In addition to the above-mentioned plants Mr. C. Cullen collected a single specimen of a Rhyncotous insect, which has been already described under the name of *Cicada ? Lowei* by R. Etheridge, Junior, and A. Sidney Olliff.[2]

The Fish Beds are succeeded conformably by white siliceous shales which do not appear to be fossiliferous. They consist of silica in a very fine state of division, but microscopic examination has failed to reveal definite traces of any organisms. Their thickness is about fifteen feet. The following analysis of this rock has been made by Mr. J. C. H. Mingaye, F.C.S. :—

Moisture at 100° C....	·40
Combined water	1·04
Silica...	97·02
Alumina and trace of ferric oxide...	1·70
Magnesia	·18
Soda	trace
	100·34

A siliceous ironstone conformably overlies these shales, its thickness being approximately seven feet. Ferruginous solutions derived from it have in places permeated the white shales below. A well waterworn and rather coarse gravel of inconsiderable thickness succeeds the ironstone, as far as can be judged from the somewhat obscure sections, and is locally cemented by the latter. Among other rocks the gravel contains undoubted pebbles of sandstone of the Hawkesbury Series, showing it to be decidedly newer than that formation.

The gravels are capped by a very coarsely crystalline olivine-dolerite, having a maximum thickness near its northern extremity, as shown on the plan, of about sixty feet. A small patch of basalt is observable near the south-west corner of Boyce's Selection, and is possibly newer than the dolerite.

[1] *Vide* also Ann. Rep. for Dep. Mines N. S. Wales 1889 [1890], p. 237.

[2] Mem. Geol. Survey N. S. Wales, Pal. No. 7. The Mesozoic and Tertiary Insects of New South Wales, by R. Etheridge, Junior, and A. Sidney Olliff. 4to. Sydney, 1890. By Authority. The Authors state (*op. cit.* p. 3), "It is exceedingly probable, therefore, that, although of Lower Mesozoic age, the beds containing the Talbragar fossils will be found to be higher, stratigraphically, than the Gosford fish-bed."

No definite evidence was obtained as to the age of these volcanic rocks, with the exception of the fact already mentioned that they cover gravels which are newer than the sandstone of the Hawkesbury Series.

Conclusions with regard to the age of the Fish Beds.—The stratigraphical evidence obtained would seem to indicate that these beds were deposited in a hollow of erosion in the sandstones of the Hawkesbury Series for the following reasons:—

(1) The Fish Beds differ in lithological character from any rock known to occur elsewhere in the Hawkesbury Series.

(2) They thin out rapidly against the sandstone of the latter formation, which rises to a considerable height on their margin, and is nowhere seen to overlie them.

The evidence supplied by the fossil plants from the Fish Beds, as provisionally interpreted by Mr. R. Etheridge, Junior (*op. cit.*), implies that these beds may be the equivalents of the Bellarine Series of Victoria, and of the Ipswich Series of Queensland with relations to the Clarence Series of N. S. Wales. Our own observations show that there is a distinction between the flora of the red shales (which latter were unknown to Mr. Etheridge, and which are undoubtedly referable to the Hawkesbury Series) and that of the Fish Beds, and as these two deposits are only a mile distant from one another, they are probably separated from one another by a considerable interval of geological time.

The early Mesozoic Flora of Australia characterised by *Thinnfeldia*, *Tæniopteris*, and *Podozamites*, probably had a considerable vertical range, as was the case with the *Glossopteris* Flora which preceded it, certain species in the latter having been proved to have been persistent through at least eight thousand feet of strata. As the beds containing the first-named flora have a thickness in places, as in Victoria, according to Mr. R. A. F. Murray, F.G.S., of about twenty thousand feet,[1] it is not unreasonable to suppose that their upper portion is of Jurassic age, a conclusion already adopted by Mr. R. L. Jack, F.G.S., in his classification of the Queensland rocks.

Mr. A. S. Woodward in this Memoir argues a Jurassic age for the Talbragar Fish Beds, basing his conclusions on the affinities of the fossil fish. There is nothing in the stratigraphical evidence obtained by us, nor in the provisional report on the associated fossil plants by Mr. R. Etheridge, Junior, to disprove this opinion. On the contrary, the balance of the evidence is, we think, in favour of it.

T. W. EDGEWORTH DAVID.
EDWARD F. PITTMAN.

[1] Victoria. Geology and Physical Geography. 8vo. Melbourne, 1887. By Authority, p. 95.

I.—INTRODUCTION.

Every new collection of fossils from the Hawkesbury-Wianamatta Series of New South Wales is of great interest, as contributing further towards the solution of the difficult problem of the age of this remarkably barren formation. That part of it, at least, is referable to the Triassic period, has long been a common belief; and the fine collection of fossil fishes from Gosford, described by the present Writer four years ago, exhibits an unmistakable Keuper or Rhætic facies. That the upper part of the Wianamatta beds may be later than the Trias, has also been suspected; and it is the object of the present Memoir to describe a new fish-fauna from the banks of the Talbragar River, which seems to have an important bearing upon the question.

The first indications of the fauna now made known, were obtained by Mr. Arthur Lowe, and the district was subsequently examined by Mr. William Anderson, who was unable to arrive at any very definite conclusions as to the stratigraphical position of the fish-bearing horizon.[1] [2] A large collection was made by Mr. Charles Cullen, who had previously been so successful at Gosford; and it now seems possible, after a careful study of the specimens in connection with the unique series of fossil fishes in the British Museum, to determine that the Talbragar strata are much newer than any other part of the Hawkesbury-Wianamatta Series that has previously yielded fish-remains. The following Memoir demonstrates, in the opinion of the present Writer, that the period cannot be earlier than that of the Lias.[3]

The specimens from the Talbragar River are in a much more satisfactory state of preservation than those from Gosford; and, like the latter, they are quite as interesting and novel from the point of view of the philosophical Palæontologist as from the standpoint of the Stratigraphical Geologist. They occur chiefly as impressions in a hard ferruginous flagstone,

[1] Our examination of the stratigraphical relation of this horizon was made subsequent to the completion of the MS. of Mr. Woodward's Memoir. *Vide* introductory note by us on the stratigraphy of the beds.—T.W.E.D., E.F.P.

[2] W. Anderson, "On the Stratigraphical Position of the Fish and Plant-bearing Beds on the Talbragar River, Cassilis District, N. S. Wales," Records Geol. Survey N. S. Wales, 1889, I, pp. 137–139, pl. xiv.

[3] A. S. Woodward, "On the Discovery of a Jurassic Fish Fauna in the Hawkesbury-Wianamatta Beds of New South Wales," Rept. Brit. Assoc., 1890, p. 822.

traversed by numerous small fissures; while the bones themselves, or the hollows which traversed them, are frequently replaced by ochreous material. The canal of the "lateral line" is often shown in this condition. The fishes are crowded together in shoals, as if suddenly destroyed; and very few of them have become disintegrated before fossilization. A glance at the accompanying plates will show how beautifully even the most delicate bones and fin-rays are usually preserved.

All the fishes from the Talbragar horizon represent new species, and three of them belong to remarkable new genera. The Memoir has, indeed, been much delayed by the novelty of the collection, which seemed to demand a very careful study of all the known Jurassic fishes before any description could be attempted. This study is now almost completed, and the results will appear in the forthcoming third part of the "Catalogue of Fossil Fishes in the British Museum," which may be consulted for a detailed discussion of the subject.

It may be added that all measurements given in the Memoir are expressed as decimal fractions of the metre.

II.—DESCRIPTION OF THE GENERA AND SPECIES.

Subclass—**Teleostomi.**

Order—CROSSOPTERYGII.

Suborder—*ACTINISTIA.*

Family—CŒLACANTHIDÆ.

Genus non det.

Plate II, Fig. 1.

The ventral portion of the abdominal region of a Cœlacanth fish of moderate size is the first and only evidence of a Crossopterygian hitherto discovered in the Hawkesbury-Wianamatta Series. One of the pectoral fins is well preserved, and at a distance of about 0·14 behind the insertion of this, there occur some fragmentary dermal rays evidently of a much smaller pelvic fin. No part of the squamation of the trunk, however, can be distinguished, and it is impossible to attempt even a generic determination of the specimen.

The pectoral fin is preserved in counterpart, and the best impression is shown of the natural size in Pl. II, Fig. 1. It exhibits, as usual, the characteristic obtuse lobation and the large fringe of articulated, attenuated dermal rays; but the fossil is as yet unique, so far as the Writer is aware, in displaying some of the endoskeletal supporting bones. These elements seem to have been well ossified, though with persistent cartilage internally. At the base of the fin there occurs an elongated broken fragment of bone, incapable of determination; but in the lobe of the fin itself there is a series of four well-defined hour-glass-shaped supports. Of these bones the anterior three are much elongated and nearly equally slender, while the fourth is much more robust and widely expanded at the distal end. The four elements radiate from the anterior half of the base of the fin; and it seems very probable that some smaller cartilages behind and near the distal border of the lobe have disappeared from lack of ossification. The fin-rays gradually increase in length from the anterior border to the middle of the lobe, whence they

decrease again backwards and finally become extremely delicate. The transverse articulations are very numerous and begin not far from the base of the rays; while distal bifurcation is conspicuous in all but about ten of the anterior rays.

To demonstrate the striking difference between the Cœlacanth fin thus described and the obtusely lobate pectoral of the existing Crossopterygian *Polypterus*, an outline-sketch of the latter is given in Pl. II, Fig. 2. It will be observed that in *Polypterus* the endoskeletal supports of the lobe are arranged much as in modern sharks, whereas those of the Cœlacanth more closely approach the basalia of an ordinary Actinopterygian fish.

Order—ACTINOPTERYGII.

Family—PALÆONISCIDÆ.

Genus—COCCOLEPIS, *Agassiz*, 1844.

(Poiss. Foss., II, Pt. 1, p. 300.)

Gen. Char.—Trunk elegantly fusiform. Mandibular suspensorium oblique; dentition consisting of an inner series of large laniaries flanked externally with minute teeth; external bones tuberculated or rugose. Fins large or of moderate size, all the rays articulated and branching distally; fulcra minute or absent. Pelvic fins extended; dorsal and anal fins triangular, the former opposed to the space between the latter and the pelvic fins; upper caudal lobe much elongated, the fin deeply cleft and somewhat unsymmetrical. Scales thin and deeply imbricating, ornamented with tuberculations of ganoine.

Obs.—The genus thus defined is represented by small species in the Lithographic Stone (Lower Kimmeridgian) of Bavaria[1], and in the Purbeck Beds[2] and Lower Lias[3] of England. It is therefore of much interest to find a large fish in the Hawkesbury-Wianamatta Series of Talbragar exhibiting characters so similar as not to be more than specifically distinguishable.

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[1] *Coccolepis Bucklandi*, L. Agassiz, Poiss. Foss., 1844, Pt. i, p. 300, pl. xxxvi, figs. 6, 7.

[2] *Coccolepis Andrewsi*, Smith Woodward, Brit. Mus. Cat. Foss. Fishes, 1891, Pt. ii, p. 524.

[3] *Coccolepis liassica*, Smith Woodward, Ann. Mag. Nat. Hist., 1890, v. [6] p. 435, pl. xvi, figs. 2-4.

COCCOLEPIS AUSTRALIS, *Smith Woodward.*

(Mus. Cat. Foss. Fishes, 1891, Pt. 2, p. 525.)

Plate I; Plate II, Fig. 4; Plate V, Fig. 1.

Obs.—This appears to be a rare species, but the examples in the collection afford much new information concerning the skeleton of the Mesozoic Palæoniscid fishes, and are thus of considerable importance. They may be enumerated as follows:—

(*a*) Large head and abdominal region in counterpart, wanting the extremity of the snout, to be regarded as the type specimen (Pl. I, Fig. 1).

(*b*) End of caudal region of an equally large fish (Pl. II, Fig. 4).

(*c*) Small individual, imperfectly preserved but nearly complete (Pl. 1, Fig. 2).

(*d*) Still smaller fish exhibiting the greater part of the fins (Pl. V, Fig. 1).

The specific identity of the two last-mentioned specimens with the foregoing is not quite certain; but they seem to differ only in the relatively great length of the joints of the fin-rays, a character regarded with good reason as denoting immaturity among Palæoniscidæ.

Sp. Char.—A very large species, attaining a length of at least 0·35. Maximum depth of trunk comprised about six times in the total length of the fish; head longer than deep. Pelvic fins relatively large, arising about midway between the pectorals and the anal; dorsal fin arising at the middle of the back, of moderate size, its maximum depth not greater than that of the trunk at its point of origin; anal fin somewhat smaller. Scales of moderate size, the exposed area rhombic in shape, ornamented with numerous closely arranged tubercles, often elongated and in horizontally directed parallel series.

Head and Opercular Apparatus.—The general form of the head is well shown, the mandibular suspensorium being very oblique, the gape wide, the cranium elongated, and the snout projecting some distance in advance of the mouth. The robust character of the pterygo-quadrate arcade is indicated in the type specimen (Pl. I, Fig. 1*a*, *u*), and there are obscure impressions of the cranial roof-bones and mandibular elements in No. *c* (Pl. I, Fig. 2). The ethmoidal region in the latter fossil also exhibits an external ornament of

elongated tubercles or rugæ (some enlarged in Fig. 2*a*). Some indefinite impressions in the type specimen denote the presence of large, widely-spaced, conical teeth, and there are indications of a series of minute, closely-arranged denticles in the mandible of No. *c*. Obscure remains, apparently of calcified filamentous appendages of the gill-arches occur behind the head in the latter specimen; and the opercular apparatus, though not clearly shown in either fossil, must have been narrow. Seven or eight branchiostegal rays, which are broad, expanding distally, and externally tuberculated, are observed beneath the mandible on one side of the type specimen (Pl. I, Fig. 1*a*, *br*), while there occurs an undetermined plate (*x*), possibly infraclavicular, below the hinder three.

Axial Skeleton of Trunk.—As is well shown by the first two specimens (Pl. I, Fig 1; Pl. II, Fig. 4), the notochord must have been persistent, and there are no undoubted traces of ossifications in the notochordal sheath. In the abdominal region there are not less than thirty-five neural arches, each opposed to a pair of small hæmal elements, which are probably homologous with those of a Sturgeon, formed externally to the notochordal sheath; in the caudal region the number of arches cannot be satisfactorily counted. The pedicles of the neural arches in the abdominal region are both robust and elongated, and appear to have remained separate at their upper extremity; the corresponding neural spines are apparently a little calcified, longer and more slender than the pedicles, and not fused with these but merely apposed by the two short limbs of their forked base. In the caudal region the hæmal resemble the neural arches and are about equal in size, except quite anteriorly where they somewhat exceed the latter in development. At the commencement of the caudal region the neural arches become abruptly smaller than those of the abdominal region, and the spines are fused with the pedicles; the whole arch is, indeed, scarcely larger than the pedicles alone of the last abdominal arch. More posteriorly, however, the size somewhat increases owing to the length of the slender neural spines, which subsequently decrease to the caudal pedicle, and gradually become more inclined to the vertebral axis. The inferior caudal lobe is supported as usual by especially thickened hæmal arches (Pl. II, Fig. 4), and the fulcral scales at the base of the upper caudal lobe rest upon a regular, close series of slender rods, which may be either neural spines or fin-supports distinct from the very rudimentary neural arches beneath them.

Appendicular Skeleton.—The pectoral fins are too imperfectly preserved for description, and were evidently feeble[1]; but the rays are well

[1] All the rays shown in the original of Pl. V, Fig. 1, seem to have been distantly articulated.

displayed in the other fins, and are shown to have been all articulated to the base, with distal bifurcation into fine filaments. The pelvic fins are much disturbed, but distinctly longer than deep in the type specimen, and in No. *d* (Pl. I, Figs. 1, 1*b*; Pl. V, Fig. 1), and the broad closely articulated ray (*ex*) to the number of about forty are finely tuberculated on their anterior border. In advance of the rays there are a few short basal fulcra, gradually increasing in length and all supported by one robust endoskeletal cartilage; the later being the foremost of a series of rod-like basal cartilages (*end.*) which support the pelvic fin exactly as in the Sturgeons. The dorsal fin is large and triangular, acuminate, arising in advance of a point opposite the hinder extremity of the pelvic fins, and no fulcra are preserved on its anterior margin. The supports are very long and slender, superficially calcified and expanded at their articulation with the fin-rays; they are only slightly less numerous than the latter, about seven supports corresponding to nine rays. The anal fin is smaller than the dorsal and in great part behind the latter, but similarly supported by long slender cartilages (Pl. I, Fig. 2; Pl. II, Fig. 4; Pl. V, Fig. 1.) The caudal fin is not quite symmetrical, the upper lobe being the largest, and the principal rays of the lower lobe the stoutest; fulcra are prominent both above and below, the former as usual being much the largest, and all, so far as can be ascertained, uniserial.

Squamation.—All the scales, except those of the upper caudal lobe, are very thin and deeply overlapping, almost cycloidal in form, but with a rhombic exposed area (Pl. I, Figs 1*c*, 1*d*.). The wide overlapped margin exhibits the fine concentric lines of growth; the exposed portion is ornamented with tubercles of ganoine, which tend towards an arrangement in horizontal parallel lines. The scales of the flank are not deepened, while those of the ventral aspect are not narrowed; and there are no indications of thickened or enlarged ridge-scales except on the upper caudal lobe. This lobe is very long and slender, and is covered as usual on the sides with stout rhombic scales, which exhibit a fine tuberculation.

Coccolepis (?), *sp.*

Plate II, Fig. 3.

Another example of a Palæoniscid fish is too imperfectly preserved for precise determination; but it evidently belongs to a genus with thin scales, while the arrangement of the fins and dentition is not inconsistent with its

reference to the genus *Coccolepis*. The fossil may even be an obscure specimen of *C. australis*, preserved merely as an impression covered with a layer of soft calcareous material; but in any case it seems advisable to append a brief description and figure for future reference.

The specimen is shown of two-thirds the natural size in Pl. II, Fig. 3, and wants only the caudal fin. All the parts, however, are very obscure, and it seems likely that the trunk is accidentally deepened by crushing and by the spread of the calcareous material. In the head a feeble semicircular depression indicates the forward position of the eye; and other outlines are evidently caused by the large pterygo-quadrate arcade. The maxilla, of the characteristic Palæoniscid form, shows impressions of a spaced series of large laniary teeth, with an adjoining close series of minute teeth; and beneath the position of the mandible there are traces of the short and broad branchiostegal rays. The axial skeleton of the trunk is not exhibited, except very feebly at the base of the caudal fin, where there is nothing worthy of remark. The rays of all the fins are robust, articulated, and bifurcating distally; but it is not possible to distinguish fulcra. One of the pectoral fins displays a few robust anterior rays, with very delicate much-divided rays behind; and the base of the pelvic fins seems to be considerably extended. There are also feeble traces of the series of pelvic fin-supports, somewhat emphasised in the drawing. The dorsal fin, as preserved, is larger than the anal and completely in advance of the latter; while the position of the caudal fin is indicated only by the bases of a few of its inferior rays. There are impressions of some large fulcra at the origin of the upper caudal lobe.

Family—SEMIONOTIDÆ.

Obs.—It has hitherto been the custom to include among the characters of this family the presence of enamelled rhombic scales. There seems to be no doubt, however, that the two remarkable new genera described immediately below are correctly placed here; and yet the second has part of the caudal region covered with deeply overlapping cycloidal scales, ornamented only with sparse tubercles of ganoine. It would, therefore, not be surprising to discover a member of the family enveloped entirely in such scales—a parallel instance to the inclusion of the genus *Cryphiœolepis* in the family of Palæoniscidæ.

Genus—APHNELEPIS, *gen. nov.*

Gen. Char.—Trunk fusiform and laterally compressed. Head of moderate size with acuminate snout, and more or less ornamented with rugæ and tubercles; marginal teeth small, stout and almost conical, closely arranged; inner teeth almost granular. Notochord persistent, sometimes with small hypocentra and pleurocentra in the caudal region; ribs long. Fin-rays all branched and articulated distally, but simple in the proximal portion; fulcra conspicuous on all the fins. Pectoral fins of moderate size, somewhat larger than the pelvic pair, which are well developed; dorsal and anal fins acuminate and short-based, the former almost or completely in advance of the latter; caudal fin forked. Scales rhombic; thin on the abdominal, still thinner on the caudal region; those of the flank deeper than broad, those of the dorsal and ventral borders about as deep as broad; ridge-scales not enlarged.

Obs.—The genus thus described much resembles *Semionotus*, but is readily distinguished by the characters of the squamation. Detached flank-scales in many respects similar to those of the type species, *A. australis*, described below, are known from the Letteukohle (Middle Trias) of Würtemberg under the name of *Serrolepis suevicus*.[1]

APHNELEPIS AUSTRALIS, *sp. nov.*

Plate III, Fig. 1–4.

Obs.—There are five important specimens illustrating this species, all in a tolerably good state of preservation :—

(*a*) The type specimen, much fractured (Pl. III, Fig. 1).

(*b*) Fish in counterpart, wanting the dorsal margin, and displaying the forked caudal fin; the head, pectoral fin, and anterior scales shown in Pl. III, Fig. 2.

(*c*) Imperfect fish, displaying the proportions of the paired and anal fins (Pl. III, Fig. 3).

(*d*) Fragmentary specimen in counterpart, displaying the scale-ornament in impression (Pl. III, Fig. 4).

(*e*) Fragmentary head and anterior abdominal region.

[1] W. Dames, "Die Ganoiden des deutschen Muschelkalks," Palæont. Abhandl., 1888, IV, p. 171, pl. xiii., figs. 4–8.

Sp. Char.—The type species, attaining a length of about 0·2. Length of head with opercular apparatus contained about one-and-a-half times in the maximum depth of the trunk, and somewhat less than one-quarter of the total length of the fish; the caudal pedicle one-third as deep as the abdominal region at its highest point where the dorsal fin arises. Pelvic fins arising opposite the origin of the dorsal, and the latter completely in advance of the anal; dorsal rays about fourteen, anal rays ten in number. Scales ornamented with coarse crimpings, which are slightly radiating, and usually confined to the hinder half.

Head and Opercular Apparatus.—The head of all the specimens is only imperfectly shown in impression. The form of the cranial roof is indicated in the original of Pl. III, Fig. 3, where the impressions of the lateral sensory canals form deep grooves; and the proportions of the orbit, crossed by the parasphenoid, are shown in the type (Pl. III, Fig. 1). There are traces of coarse rugæ and tubercles on the cranial roof (No. *e*); the facial bones seem to have been more finely tuberculated (No. *b*); and there are impressions of sparse elongated tubercles on the branchiostegal rays in No. *d*. A regular, close marginal series of small, stout, conical teeth can be distinguished (Pl. III, Fig. 3); and there are indications apparently of minute granular teeth on some of the inner bones of the mouth. The gular plate is large (Pl. III, Fig. 2), and it is followed behind by short and broad branchiostegal rays. There is no definite information as to the form and proportions of the operculum and suboperculum.

Axial Skeleton of Trunk.—There seem to have been no ossifications in the notochordal sheath in the abdominal region; but distinct pleurocentra and hypocentra are observable in the caudal region, especially in the type (Pl. III, Fig. 1). The neural and hæmal arches are also well ossified in the caudal region, but apparently less so in the abdominal region; and it is difficult to decide whether there were well-developed ribs, although appearances in Nos. *b* and *c* are suggestive of such having been present. The hæmal arches, as usual, become especially robust at the base of the caudal fin.

Appendicular Skeleton.—No satisfactory remains of the arches supporting the paired fins are preserved, the clavicle only being recognisable as a sickle-shaped bone with a few longitudinal striations near its postero-inferior border. All the fins exhibit fulcra, which seem to be uniserial, and are largest on the upper lobe of the tail. The fin-rays are undivided for some

distance from the base, and then bifurcate twice, at the same time becoming jointed by distant articulations. Each pectoral fin comprises not less than thirteen rays (Pl. III, Fig. 3), of which the anterior five are closely adpressed, and exhibit an especially long unjointed base, while the posterior three or four are very short and delicate; each pelvic fin probably had not more than six rays (Pl. III, Fig. 3). The dorsal fin (Pl. III, Fig. 1), arising at the highest point of the back exactly opposite the pelvic fins, is much deeper than long, comprising about fourteen rays, of which the second is longest, and nearly three times as long as the hindermost; it exhibits a few large basal fulcra continued as a conspicuous series along the front border of the fin, and each fin-ray is supported by a distinct, well ossified interspinous bone. The anal fin (Pl. III, Figs. 1, 3) resembles the dorsal, but is smaller, exhibiting apparently only ten rays. The rays of the caudal fin (Pl. III, Fig. 1) are articulated from a point much nearer to the base than those of the other fins, and they are much more numerous than the supporting hæmal spines; a few large deeply imbricating ridge-scales on the atrophied upper caudal lobe pass into the conspicuous fulcra of the upper margin, while another large scale is seen at the base of the lower lobe; the hinder margin of the fin is moderately forked.

Squamation.—The aspect of the squamation varies considerably in different specimens, according as it is exhibited from within or without, in ferruginous material or in perfectly hard impression. It is, however, evident that the whole trunk is covered with scales, and that those in advance of an oblique line from the origin of the dorsal to the origin of the anal-fin are comparatively thick, while those behind suddenly become very thin. All the scales are rhomboidal in form, and considerably imbricating, those of the dorsal and ventral aspects nearly as broad as deep, while about six principal flank-series, at least in the abdominal region, are much deeper than broad. The true external form of some of the latter seems to be given in the enlarged drawing, Pl. III, Fig. 4; and there are appearances in the ferruginous specimens No. *c* (Pl. III, Fig. 3), which may possibly be interpreted as indicating that these scales were united above and below by a broad peg-and-socket articulation. All the scales (except perhaps the few rhombic scales on the atrophied upper caudal lobe) are externally ornamented at least in their hinder portion with nearly parallel, straight, acute ridges, each of which usually terminates at the hinder border in a feeble denticulation, and is sometimes continued in front by delicate striæ. These ridges, though occasionally somewhat radiating, mostly extend in the direction of the long axis of the

trunk, and are thus directly transverse on the flank-scales, while more or less oblique on the equilateral scales dorsally and ventrally. The lateral line produces no external ridge, but the large canal, filled with ferruginous material, is conspicuous in the original of Pl. III, Fig. 3.

APHNELEPIS, *sp.*

Plate III, Fig. 5.

One fragmentary specimen, in counterpart, proves that *Aphnelepis* sometimes attained twice the size of the fishes just described; but there is as yet no means of determining whether this fossil is specifically distinct from *A. australis* or whether it merely represents a gigantic individual. The dorsal fin and some of the scales are shown of the natural size in Pl. III, Fig. 5. So far as can be ascertained, the fin agrees with the dorsal of *A. australis* in all essential respects; and there is nothing worthy of remark in the squamation, except that the posterior denticles of the dorsal scales are especially prominent. It is, however, interesting to note that there are undoubted remains of well-developed ribs.

Genus—AETHEOLEPIS, *gen. nov.*

Gen. Char.—Trunk deep and laterally compressed; head small, and external bones more or less tuberculated. Notochord persistent, apparently without ossifications in the sheath. Fin-rays robust, all branched and closely articulated distally, but simple in the proximal portion; fulcra well developed. Pectoral fins placed laterally; pelvic fins of moderate size; dorsal and anal fins much extended, acuminate in front, and both remotely situated; [? caudal fin not forked]. Scales of abdominal region thick, much deeper than broad on the flank, quadrate in form, moderately overlapping, with large peg-and-socket articulation and an anterior inner longitudinal keel, the scales of this form gradually passing into those of the caudal region, which are very thin, deeply imbricating, and more or less oval in shape. Scale-ornament consisting of tubercles.

AETHEOLEPIS MIRABILIS, *sp. nov.*

Plate III, Fig. 6; Plate IV, Figs. 1–7.

Obs.—The materials upon which this genus and species are based, clearly exhibit all the more important characters of the fish, except the dentition and the extremity of the caudal fin. They comprise the following specimens:—

(*a*) The type specimen, partly preserved in counterpart, and shown of the natural size in Pl. IV, Fig. 1.

(*b*) Imperfect head and abdominal squamation, in counterpart.

(*c*) The scattered remains of a fish, among which many scales are well shown (Pl. IV, Figs. 2–7).

(*d*) Imperfect caudal region, partly shown of the natural size in Pl. III, Fig. 6.

Sp. Char.—The type species, attaining a length of about 0·17. Length of trunk from the pectoral arch to the base of the caudal fin equalling scarcely more than three-quarters of the maximum depth; the dorsal margin gibbously curved, the ventral margin more regularly arched. Head with opercular apparatus occupying slightly more than one-quarter of the total length of the fish to the base of the caudal fin. Pelvic fins arising much nearer to the anal than to the pectorals; the dorsal fin, with about twenty-four rays, arising considerably in advance of the middle point of the back and extending nearly to the base of the caudal fin; the anal fin, with seventeen rays, opposed to the hinder two-thirds of the dorsal, and the length of its foremost ray equalling nearly half of the maximum depth of the trunk. The thickened abdominal squamation terminating abruptly at a line joining the origin of the dorsal and anal fins.

Head and Opercular Apparatus.—The cranium is short and triangular, deeper than broad (Pl. IV, Fig. 1), and the frontal profile is angulated, there being a rounded bend in the roof immediately in advance of and above the orbital space. None of the elements of the cranial roof can be distinguished; but there seems to be a large, paired, square element behind, which is evidently supra-temporal. The narrow forward extension of the parasphenoid bone is conspicuous below the orbit; and immediately beneath this is a large smooth plate, longer than deep, representing a well-developed bony pterygo-quadrate arch. The form and proportions of the jaws are indistinguishable; and unless some obscure indications in the type specimen are produced by a cluster of minute, short styliform teeth, there is no evidence of the dentition. The opercular apparatus is narrow: and unless appearances are deceptive in No. *b*, the operculum is especially deep in proportion to its width. So far as shown, all the head and opercular bones are externally tuberculated.

Axial Skeleton of Trunk.—The axial skeleton of the trunk is exposed only in the hinder portion of the fish, where the thinness of the squamation permits of its being distinctly observed. The notochord must have been persistent, and the short, expanded neural and hæmal arches in the caudal

region are firmly united to a series of long neural and hæmal spines, which diminish in size towards the caudal pedicle. Like the supports of the median fins, these are only superficially ossified, an inner rod of matrix showing the extent to which the cartilage persisted.

Appendicular Skeleton.—As shown by an impression in No. *b*, the inferior expanded end of the clavicle slightly turns forwards, appearing as if abruptly truncated; while the pectoral fin is placed just above the ventral border of the fish, and seems to have comprised only articulated rays. The pelvic fins (Pl. IV, Fig. 1) also consist of articulated and distally bifurcating rays; they are relatively small though deep, having a remarkably short base-line. The pelvic fin-supports are not shown. All the rays of the median fins are remarkably broad and robust, closely articulated and finely divided from a point a short distance above the base; the sub-divisions terminating in fine filaments distally. In the dorsal and anal fins the rays are widely spaced, very long in front but gradually decreasing in length behind. The foremost ray of the anal (and presumably also that of the dorsal) is the longest; and at its base is a series of large, elongated fulcra, which pass upwards into a fine fringe upon the ray. The fin-supports (Pl. III, Fig. 6, *b*) are also very robust, forked and expanded at their distal end for union with the fin-rays (*r*), which they distinctly equal in number; and all these bones are much elongated, their proximal or inner ends overlapping and extending between the neural and hæmal spines of the axial skeleton. There are about seventeen rays in the anal fin, and not less than twenty-four in the dorsal. In the caudal fin the rays are more closely arranged than in the other median fins; there are distinct small fulcra on the upper and lower border, and the hinder border does not seem to have been excavated, although the specimens are scarcely sufficient to decide this character.

Squamation.—In the anterior half of the trunk (Pl. IV, Fig. 1), as far as an oblique line joining the origin of the dorsal and anal fins, the scales are relatively thick, quadrangular, and closely united by the well-known peg-and-socket articulation (Pl. IV, Figs. 2, 2*a*). Along the dorsal and ventral borders there seems to have been an azygous series of scales, but these are not enlarged; and it is not possible to determine whether or not there were any especially large scales along the hinder margin of the clavicle. The thick quadrangular scales are moderately overlapped, and exhibit an inner vertical keel near the anterior border, which is prolonged upwards into a very long articulating peg. The principal scales of the flank (Pl. IV, Fig. 2) are

two or three times as deep as broad, while those situated dorsally and ventrally (Pl. IV, Fig. 3) are more nearly equilateral. The exposed area in all is somewhat rhomboidal in shape—especially so in the dorsal and ventral scales; and the external ornament consists of numerous fine tuberculations, with an occasional tendency to arrangement in lines concentric with the free borders.

In the caudal region, behind the line already mentioned, the scales become immediately thin, deeply overlapping, and cycloidal. As shown by the fine group of remains (No. *c*), there appears to be some gradation from these scales to those of the abdominal region just described; and the original of Pl. IV, Fig. 5, is evidently to be regarded as one of the intermediate forms. Here the overlapped area occupies nearly half of the scale; the upper peg is broad and short; the concentric lines of growth are distinct, and the superficial tuberculations more clearly follow these than in the majority of the scales of the abdominal region. Except near the dorsal and ventral borders, the cycloidal scales are ovoid in shape, with the long axis vertical; and a typical specimen of the series traversed by the lateral line is shown in Pl. IV, Fig. 6. The exposed area now forms only a deep sector extending backwards from the middle point of the scale; and the anterior half was evidently overlapped by parts of two scales, one above and one below. There is a short, horizontal, raised line immediately behind the middle of the scale, probably indicating a perforation for the passage of the lateral sensory canal; and the exposed sector is ornamented in the usual manner by tuberculations following the lines of growth. An imperfect scale from the lower part of the caudal pedicle (Pl. IV, Fig. 7) shows that in this region the scales are nearly as broad as deep; and in the type it is quite clear that there was no postero-superior production of the caudal region into a lobe.

Family—PHOLIDOPHORIDÆ.

Genus—ARCHÆOMENE, *gen. nov.*

Gen. Char.—Trunk fusiform and laterally compressed; atrophied upper caudal lobe conspicuous. Head small and snout obtuse; one large suborbital occupying the greater part of the cheek behind the orbit; oral border of maxilla convex; teeth all small, those of the margin of the jaws arranged in close regular series. Notochord persistent; hypocentra and pleurocentra rudimentary or absent; ribs long and slender. Fin-rays all

branched and articulated distally, but simple in the proximal portion; fulcra small. Pelvic fins nearly as large as the pectorals; dorsal and anal fins acuminate and opposed, the former short-based, the latter more extended; caudal fin forked. Scales thin, deeply imbricating, and almost cycloidal, those of the flank not deepened, and those of the dorsal and ventral aspect about as deep as broad; conspicuous obtuse ridge-scales dorsally and ventrally.

Archæomæne tenuis, *sp. nov.*

Plate II, Figs., 5, 6.

Obs.—Three well-preserved specimens make known all the principal characters of the type species of *Archæomæne*, and may be enumerated thus:—

(*a*) The type specimen, a nearly complete fish shown of the natural size in Pl. II, Fig. 5.

(*b*) Slab with two smaller fishes, the tail of one shown in outline, twice natural size, in Pl. II, Fig. 6.

(*c*) Fish 0·075 in length.

Two imperfect examples of the trunk of a much larger fish may also pertain to this species; and if so it must sometimes have attained a length of at least 0·18.

Sp. Char.—The type-species, commonly attaining a length of about 0·12. Head with opercular apparatus occupying somewhat less than one-fifth of the total length of the fish; and the maximum depth of the trunk equalling about one-third of the length from the pectoral arch to the base of the caudal fin. Pectoral fin with from ten to twelve rays, the foremost especially stout; pelvic fins arising midway between the pectorals and the anal, each with about six rays; dorsal fin comprising about ten rays, arising behind the middle point of the back directly opposite to the origin of the anal, which has not less than fourteen rays. Scales exhibiting only the concentric lines of growth.

Head and Opercular Apparatus.—The head is scarcely as long as deep, and the cleft of the mouth is slightly oblique. The cranial roof is truncated behind and seems to have been originally much arched from side to side. The parasphenoid in its anterior portion, as it appears across the orbit, is very slender and slightly bulging downwards; the premaxillæ are small, while the maxillaries and dentaries are conformed exactly as in

Pholidophorus. The close marginal series of minute teeth in the upper jaw is distinctly seen in the type-specimen. There appear to be supramaxillary bones corresponding with those of *Pholidophorus* and *Leptolepis;* and in the suborbital ring there is one very distinct large cheek-plate covering all the space between the orbit and preoperculum. The latter bone is narrow and arcuate, apparently not exposed in its upper portion; the operculum is quadrate and much deeper than broad, while the subopercnlum is scarcely half as deep as this element, separated from it by a somewhat oblique suture, and exhibiting a short ascending process at its antero-superior angle; the interopercnlum is relatively small and triangular. Beneath the subopercnlum there follows a series of about eight branchiostegal rays, all broad, but the foremost about as broad as long; and in one specimen on the slab No. *b*, the large gular plate is conspicuous between the anterior half of the rami of the mandible.

Axial Skeleton of Trunk.—There is no satisfactory evidence of ossifications in the notochordal sheath, but the neural and hæmal arches were all calcified, at least superficially. The long, slender ribs of the abdominal region are shown in all the specimens, apparently not quite reaching the ventral margin; but the series is not sufficiently complete to be counted. The neural and hæmal arches are shorter and stouter in the caudal region (Pl. II, Fig. 6), and almost symmetrically arranged with respect to the notochord as far as the base of the caudal fin, where the hæmals (*h*) become considerably enlarged, as usual, for the direct support of the fin-rays (*r*). There are no traces of intermuscular bones.

Appendicular Skeleton.—The crushed supratemporal and post-temporal plates are always shown above the operculum (Pl. II, Fig. 5), and it is clear that there are some post-clavicular scales behind the sickle-shaped clavicle. Nothing worthy of note, however, is shown in the pectoral arch, and not in any specimen are there distinct remains of the pelvic arch. All the fin-rays are robust and undivided for a considerable length proximally, and none are closely articulated or bifurcate more than twice distally. The fulcra are very slender and minute, and are distinctly seen on the front margin of the pectoral fin in the slender specimen on slab No. *b*. So far as can be ascertained, the pectoral fin comprises from ten to twelve rays, while the pelvic fin has only about half that number; the dorsal fin comprises ten, and the anal fin not less than fourteen rays.

Squamation.—The scales are remarkably uniform in character, thin, deeply imbricating, and almost cycloidal, exhibiting only the concentric lines

of growth (Pl. II, Fig. 5*a*). Those of the flanks are not deepened, while those of the dorsal and ventral aspects are not narrowed; but a series of sharp oblique lines on the dorsal and ventral borders evidently indicates the presence of comparatively large and robust ridge-scales. These scales are conspicuous again in No. *b*, and are shown in the outline sketch of the caudal pedicle in Pl. II, Fig. 6 (*s*). Their posterior overlapping margin appears to be truncated, and the ridge-series at the base of the upper caudal lobe is supported by slender interspinous bones (*b*).

ARCHÆOMÆNE ROBUSTUS, *sp. nov.*

Plate V, Figs. 2–4.

Obs.—There is fragmentary evidence of a second and more robust species of *Archæomæne*, which is illustrated by the following four specimens:—

(*a*) The type specimen shown of the natural size in Pl. V, Fig. 2.

(*b*) Distorted smaller fish, very fragmentary.

(*c*) Distorted caudal region shown of the natural size in Pl. V, Fig. 3.

(*d*) Smaller caudal region.

(*e*) Still smaller caudal region, part of the upper lobe shown of three times the natural size in Pl. V, Fig. 4.

One very large head, with part of the abdominal region, and another specimen showing scattered remains of the caudal region, may also pertain to this species; and, if so, the fish must sometimes have attained a length of not less than 0·3.

Sp. Char.—A species commonly attaining a length of about 0·2. Head with opercular apparatus occupying about one-fifth of the total length of the fish, and the maximum depth of the trunk equalling nearly one-half of the length from the pectoral arch to the base of the caudal fin. Dorsal fin comprising about ten rays, arising at the middle point between the occiput and the base of the caudal fin, opposite the origin of the anal fin, which has not less than fourteen rays. Scales exhibiting only the concentric lines of growth.

Axial Skeleton of Trunk.—Nothing worthy of special note is to be observed in the head and opercular apparatus; but the arches of the vertebral column are more satisfactorily displayed than in the examples of the last species. There is again no evidence of ossifications in the notochordal sheath,

and there are no intermuscular bones, but all the arches seem to have been well calcified, at least superficially. The neural arches in the abdominal region appear comparatively small; but they are surmounted, as in *Thrissops*, by a correlated series of long, free, sigmoidally-bent rods, which terminates immediately below the anterior part of the dorsal fin (Pl. V, Fig. 2). The apparent arches may thus be in reality only the pedicles, while the rods above are neural spines; on the other hand, the arrangement would perhaps be interpreted by some as a series of dwarfed neural arches, with free "interspinous bones" above. In the caudal region the neural spines are distinctly fused with the pedicles. The large ribs are shown, not quite reaching the inferior border of the abdominal region; and the hæmal spines, as usual, are much enlarged at the base of the caudal fin.

Appendicular Skeleton.—Fulcra are conspicuous on the median fins, and are also seen on the pectoral fin of No. *b*. All the pectoral fin-rays, to the number of about twelve, and all the pelvic fin-rays, perhaps about six, are unjointed for a considerable length proximally; while the articulations of their divided and jointed distal portion are all distant. The dorsal fin is shown in the type specimen to comprise ten or eleven rays, while the anal in Nos. *b* and *c* exhibits at least fourteen rays. In Nos. *c* and *d* the opposition of these two fins is clearly indicated, and the forked character of the caudal fin is also proved.

Squamation.—So far as can be ascertained, the scales differ in no respects from those of *A. tenuis*, the ridge-series having a similar aspect, and the other scales exhibiting only the concentric lines of growth. Unless, however, the small caudal region, No. *e*, is deceptive, there is evidence of a few rhombic scales on the atrophied upper caudal lobe (Pl. V, Fig. 4).

Family—LEPTOLEPIDÆ.

Genus—LEPTOLEPIS, *Agassiz*.

(Neues Jahrb. fur Mineralogie, &c., 1832, p. 146.)

Gen. Char.—Trunk elegantly fusiform. External head-bones and the opercular bones delicate, covered with smooth or feebly ornamented ganoine; snout obtusely pointed, and mandible prominent; maxilla arched, with a convex dentigerous border, and dentary sharply rising into an obtuse coronoid process near its anterior extremity; teeth minute, conical, and closely arranged; preoperculum broad mesially and marked with slight, radiating

furrows; suboperculum large, but smaller than the trapezoidal operculum, from which it is divided by an oblique suture. Vertebræ in the form of much-constricted cylinders, with little or no secondary ossification; intermuscular bones feebly developed. Fins consisting of delicate, dichotomously branching rays; fulcra absent. Pelvic fins relatively large; dorsal fin about as long as deep, opposed to the pelvic pair or to the space between the latter and the anal; anal small, not extended; caudal deeply forked. Scales very thin, cycloidal, and the exposed portion invested with continuous, smooth enamel; no enlarged or thickened ridge-scales.

Osteology of the Genus.—No satisfactory concise synopsis of all the principal osteological characters of *Leptolepis* appears to have hitherto been published. The beautiful impressions of the skeleton in the new Australian collection may therefore be utilized in attempting an amended and amplified description.

The external bones and scales are covered with a very thin layer of ganoine, always smooth or only feebly rugose. The cranial roof is flattened in the middle, abruptly truncated behind, and very narrow between the orbits; the parietals are very small, and the suture between the much-elongated frontals is wavy. The parasphenoid is delicate. There is a series of large suborbital bones, and the sensory canal traversing them exhibits a series of short branches radiating downwards. The sclerotic ring is ossified. The premaxilla is minute, and the long curved maxilla, having minute teeth on its convex oral margin, is contracted, though comparatively robust at its loose anterior articulation. There are also two elongated supramaxillary bones, deeply overlapping the maxilla. The mandible is deep in the middle, tapering at either end, and consists almost entirely (if not entirely) of two elements. The robust dentary bone is remarkable for the deep coronoid process rising nearest its anterior end; behind, and partly above it, is the large laminar articular element. The ceratohyal has the ordinary hour-glass form, but is noteworthy for the extension of a supplementary, delicate, straight rod of bone between its extremities on the upper side. The opercular apparatus is complete, and the sensory canal upon the preoperculum exhibits radiating branches resembling those of the suborbital line. The branchiostegal rays on the short epihyal are broad and imbricating, while those supported by the ceratohyal are spaced and delicate; and there is no trace of a gular plate in any specimen examined by the present Writer.

One pair of large supratemporal plates occurs behind the occiput, and the whole of the trunk is covered with imbricating cycloidal scales, which

are distinctly invested with ganoine in their exposed portion. The vertebral centra are in the form of constricted cylinders, not completely severing the intervertebral portions of the notochord; and they are often strengthened in the later species by longitudinal streaks of bone on the periphery. The ribs are robust, extending almost or quite to the ventral border; and some specimens seem to show that they are attached to broad laminar parapophyses. The delicate neural arches in the abdominal region do not appear to have been fused with the centra, while the right and left halves are separate. Above them, extending as far backwards as the origin of the dorsal fin, is a series of short free rods, commonly interpreted as "interspinous bones," but which may even be neural spines. There are also remains of some intermuscular bones. Both the neural and hæmal arches in the caudal region are much more robust and firmly united with the centrum; each consists of one piece, and has a laminar expansion at the base.

The fin-rays are all delicate, articulated, and branched distally; and fulcra are entirely absent. The pelvic bones are laminar, broadest at the base for the attachment of the fin-rays, and thickened along the outer border.

Owing to the varied character of the distortion produced by crushing, it is very difficult to determine the species of a genus of fishes like *Leptolepis*. Although there are sometimes marked differences in the skeleton, the external form and proportions of the fish must also be taken into consideration; while the larger a collection the more impossible does it appear to separate the individuals into well-defined specific groups. The arrangement of the Talbralgar Leptolepidæ proposed below, must thus be regarded as provisional; but the present Writer is unable to recognise more than three well-marked forms.

Leptolepis talbragarensis, *sp. nov.*

Plate VI, Figs. 1–8.

Obs.—This is by far the most abundant fish in the Talbragar deposit, and it is impossible to enumerate all the important specimens elucidating its characters. The following selection only is made for illustration:—

(*a*) A young specimen (Pl. VI, Fig. 1) showing well-separated vertebral rings, those in the anterior part of the abdominal region being overturned and exhibited in end view.

(*b*) A larger fish (Fig. 2) appearing much more robust, but its depth exaggerated by crushing, especially at the ventral border.

(*c*) A specimen differently crushed (Fig. 3), the trunk being probably about normal, the form and proportions of the head altered by the expansion of the mouth.

(*d*) The type specimen (Fig. 4), a well-preserved fish exhibiting all the fins. The trunk is a little distorted, as shown by the displacement of the neural arches and vertebral rings in the abdominal region.

(*e*) A large fish (Fig. 5) with the trunk much deepened by distortion, the ribs being torn away from the vertebræ and the ventral border especially displaced.

(*f*) The head and abdominal region in counterpart, one side drawn of the natural size (Fig. 6) to exhibit the axial skeleton of the trunk.

(*g*) Remains of the hinder half of a relatively large fish (Fig. 7), probably of this species.

(*h*) Fragment of fish displaying the pelvic fins with their supports, as shown of the natural size in Fig. 8.

The principal features in the drawings are well emphasised, and the detailed description of the osteology of the genus given above renders any further account superfluous.

Sp. Char.—A robust species, ordinarily attaining a length not exceeding 0·15. Length of head with opercular apparatus less than the maximum depth of the trunk, and somewhat less than one-fifth of the total length of the fish; caudal pedicle robust, nearly half as deep as the abdominal region. Vertebræ about forty-five in number, the centra scarcely longer than deep in the anterior part of the caudal region, and forming thin, smooth, constricted cylinders; the neural and hæmal arches in the anterior part of the caudal region gently arcuated, not depressed. Pelvic fins arising slightly nearer to the anal than to the pectorals; dorsal with about twelve rays, arising in advance of the middle point of the back and immediately behind the origin of the pelvic fins; anal fin, with about nine rays, arising half-way between the pelvic and caudal fins.

Leptolepis Lowei, *sp. nov.*

Plate VI, Figs. 9, 10.

Obs.—A rare new species of *Leptolepis* is indicated by a few specimens, of which two are enumerated below; and it may appropriately receive the name of *L. Lowei*, in honour of the original discoverer of the Talbragar fishes:—

(*a*) The type specimen, shown of the natural size in Pl. VI, Fig. 9. The upward displacement of the neural arches in the abdominal region suggests that the trunk had been somewhat deepened by crushing.

(*b*) A larger fish in counterpart (Fig. 10), with the ventral border displaced downwards.

Sp. Char.—A species closely resembling *L. talbragarensis*, but smaller and more slender. The head with opercular apparatus is elongated, about two-thirds as deep as long, and its length is equal to the maximum depth of the trunk.

Leptolepis gregarius, *sp. nov.*

Plate IV, Figs. 8–10; Plate V, Fig. 5; Plate VI, Figs. 11, 12.

Obs.—The numerous specimens referred to this species are all small, and bear a mark of immaturity in the circumstance that the vertebral rings are narrow and separated by considerable spaces. The proportions of the head, however, and the less remote situation of the anal fin, distinguish the fish from the associated species just described, and no intermediate forms have been observed. It may thus receive the specific name of *L. gregarius*, in allusion to the shoals in which it usually occurs. Of the numerous specimens, the following six are selected for illustration:—

(*a*) The type specimen, shown of the natural size in Pl. IV, Fig. 8. The vertebral rings are crushed so as to appear in end view, and the abdominal region is slightly deepened by the displacement of the ventral margin.

(*b*) More imperfect fish (Pl. IV, Fig. 9), displaying the caudal vertebræ in side view.

(*c*) Specimen showing minute teeth on the maxilla, some of these greatly enlarged in Pl. IV, Fig. 11.

(*d*) Slab with shoal of fishes in various states of preservation (Pl. V, Fig. 5).

(*e*) Fish shown in Pl. VI, Fig. 11, and bones of head diagrammatically outlined in Pl. IV, Fig. 10.

(*f*) Specimen somewhat deepened by distortion and with vertebral rings shown in end view (Pl. VI, Fig. 12).

The diagrammatic outline of the head given in Pl. IV, Fig. 10, shows the form and proportions of the opercular bones and cranial roof, with the parasphenoid in side view, and the supratemporal plate and clavicle; but appearances in the region of the jaws are partly deceptive. The mandible,

though usually preserved as shown, is proved by many specimens to have the form normal in *Leptolepis*, while the crushing of the pterygo-palatine arcade upon the suborbitals and supramaxillaries has caused the deceptive appearance of two great plates in the figure.

Sp. Char.—A moderately robust species of small size, resembling *L. talbragarensis*, except in the undermentioned characters. Length of head with opercular apparatus not much exceeding its depth, about equal to the maximum depth of the trunk, and occupying somewhat more than one-fifth of the total length of the fish ; anal fin arising nearer to the pelvic fins than to the caudal.

III.—CONCLUSION.

The number of genera and species represented in the Talbragar fossil fish fauna is thus comparatively small, the following being a complete list of the forms determined :—

CROSSOPTERYGII.

CŒLACANTHIDÆ.

Genus non det.

ACTINOPTERYGII.

PALÆONISCIDÆ.

Coccolepis, *Agassiz.*
„ australis, *sp. nov.*

SEMIONOTIDÆ.

Aphnelepis, *gen. nov.*
„ australis, *sp. nov.*
„ *sp.*
Aetheolepis, *gen. nov.*
„ mirabilis, *sp. nov.*

PHOLIDOPHORIDÆ.

Archæomæne, *gen. nov.*
„ tenuis, *sp. nov.*
„ robustus, *sp. nov.*

LEPTOLEPIDÆ.

Leptolepis, *Agassiz.*
„ talbragarensis, *sp. nov.*
„ Lowei, *sp. nov.*
„ gregarius, *sp. nov.*

Of these fishes, the Cœlacanth genus and *Coccolepis* may be at once dismissed as of no stratigraphical value. The three new genera and *Leptolepis*, however, admit of more satisfactory discussion.

As already remarked, the only known ichthyolites closely resembling *Aphnelepis* are some detached scales from the uppermost Muschelkalk of Germany, the Lettenkohle, which may or may not belong to a similar fish. It is, however, evident that *Aphnelepis* differs from *Semionotus* in no essential characters, except those of the squamation; and as it is now generally admitted that thin, deeply imbricating scales result from the evolution of rhombic ganoid scales, it may be inferred that the Talbragar genus is more specialised than the familiar *Semionotus*. Now, the latter fish is not

certainly known to range above the Rhætic formation; at any rate, the typical forms all occur between the Bunter and the Rhætic. Presumably, therefore, *Aphnelepis* does not represent an earlier period than the Liassic.

With regard to the remarkable genus, *Aetheolepis*, it can only be considered as a similarly specialised ally of *Dapedius*. The Dapedioid fishes are almost exclusively confined to the Lias, only unsatisfactory fragments occurring above and below. *Aetheolepis* is thus, at least, a typically Jurassic fish.

Archæomœne, again, is a typical member of the Pholidophoridæ, except as regards its cycloidal, deeply imbricating scales; and although this family ranges from the Upper Trias to the Upper Jurassic, it is especially characteristic of the Lias.

All the preceding genera, however, are rare in the Talbragar fish-bearing stratum, compared with the great shoals of *Leptolepis*. These fishes occur in hundreds in all stages of growth from the small fry to the stout adult; and the variations to be observed in the different specimens are so great that it is difficult to determine the number of species. Now, no typical example of *Leptolepis* has hitherto been discovered below the Lias; and even the forms recorded from the lower division of this formation are doubtful.[1] It is a very abundant fish in the Upper Lias, and ranges throughout the Jurassic Series, probably becoming extinct before the Cretaceous period;[2] and the Liassic forms, which are of comparatively small size, can always be distinguished from those of the Upper Oolites by the simple character of their vertebral centra. In a Liassic species the vertebral centrum is a simple, constricted cylinder; in adult individuals of a species from the Solenhofen-stone (Lower Kimmeridgian), the centra are more or less strengthened by a peripheral ossification in longitudinal streaks. The Talbragar species of *Leptolepis* belong to the former category, and thus, presumably, represent a lower horizon than the Upper Jurassic.

To sum up: *Aphnelepis* is a specialised Triassic fish. *Aetheolepis* and *Archæomœne* are advances, respectively, upon the Liassic Dapedioids and Pholidophorids, while the species of *Leptolepis* more resemble those of the Upper Lias than those of the Lower Kimmeridgian. The Talbragar fish-fauna is, therefore, probably, not earlier than the Upper Lias, and may be referable to the Lower Oolites.

[1] The so-called *Leptolepis caudalis* (Agassiz, Poiss. Foss., II. Pt. ii, p. 133) from the Lower Lias of Lyme Regis, is proved not to belong to this genus by the presence of conspicuous fulera and other characters. *Leptolepis Bronni* has been erroneously recorded from the Lower Lias.

[2] The so-called *Leptolepis neocomiensis* and *L. Neumayri* do not pertain to this genus, if Bassani's outline-sketches of the jaws are correct (Denkschr. k. Akad. Wiss., math.-naturw. Cl., 1882, XLV, pp. 204–207, pl. II, figs. 1–10.)

The interest of the collection now described, however, is not confined to stratigraphical questions. As already remarked, it adds much to our knowledge of purely philosophical Palæichthyology.

In the first place, the endoskeleton of the lobate pectoral fin of a Cœlacanth fish is discovered for the first time, and exhibits a very striking difference from the corresponding lobate fin of the living *Polypterus*. The theoretical questions involved, however, can only be satisfactorily discussed when similar examples of the fin in allied genera are known.

Secondly, the long-looked-for evidence of the Acipenseroid nature of the pelvic fin-supports in the Palæoniscidæ, is at last supplied by the beautiful large example of *Coccolepis australis*. The axial skeleton of the trunk is also better displayed in this fish than in any Palæoniscid previously described.

Thirdly, there are the very remarkable examples of the degeneration of the scales in the caudal region of the two new genera of Semionotidæ. Both in *Aphnelepis* and in *Aetheolepis* the normal squamation terminates at a line connecting the origin of the dorsal and anal fins, the scales behind this line being extremely thin; and in *Aetheolepis* it is proved that towards the end of the tail the scales become truly cycloidal. Here, probably, is the explanation of the absence of the squamation in the caudal region of some well-known genera of Pycnodont fishes (*e.g.*, *Mesodon* and *Pycnodus*); the normal rhombic scales behind the origin of the median fins may be assumed to have passed through the stage represented by *Aetheolepis* and to have finally disappeared.

Lastly, the Talbragar collection is interesting on account of the exquisite state of preservation of much of the skeleton in the innumerable Leptolepidæ. As shown by the drawings the axial skeleton of the trunk is especially well displayed, and the vertebral centra can be observed in all stages of development. The specimens do not exhibit any features that cannot also be distinguished in examples of the genus from the European Lias and Lithographic Stone; but the present study has added a few facts of importance which seem to have hitherto escaped attention.

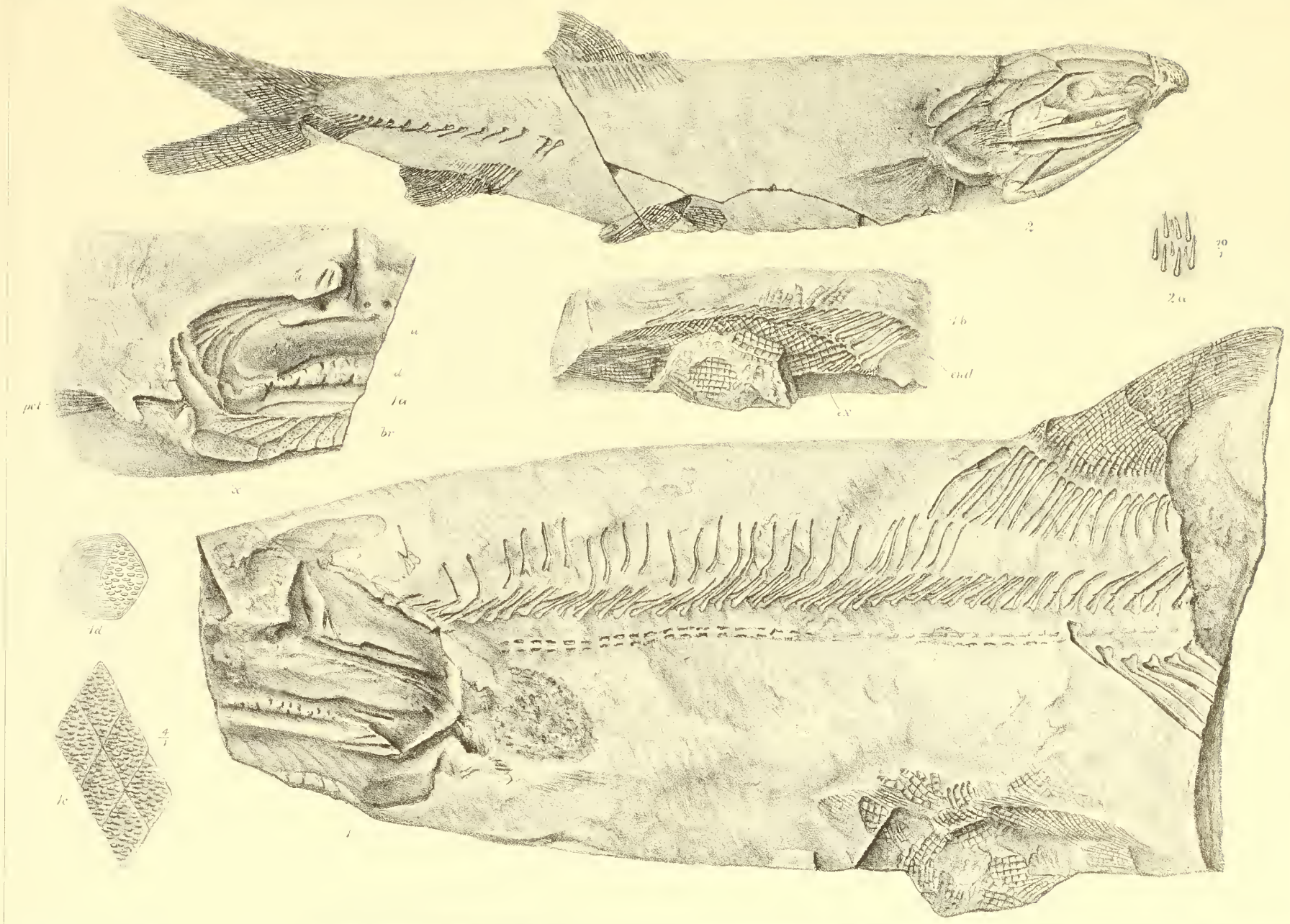
In conclusion, we cannot but remark, as has often been done before, how purely accidental are the discoveries by which Palæontology is most enriched. The little local deposit on the Talbragar River adds more essential facts to our knowledge of Jurassic fishes than many a stratum that has been known and systematically worked for decades. We can only hope that many more equally fortunate discoveries will be made as the Geological Survey of New South Wales progresses.

INDEX TO THE GENERA AND SPECIES.

EXPLANATION OF PLATES.

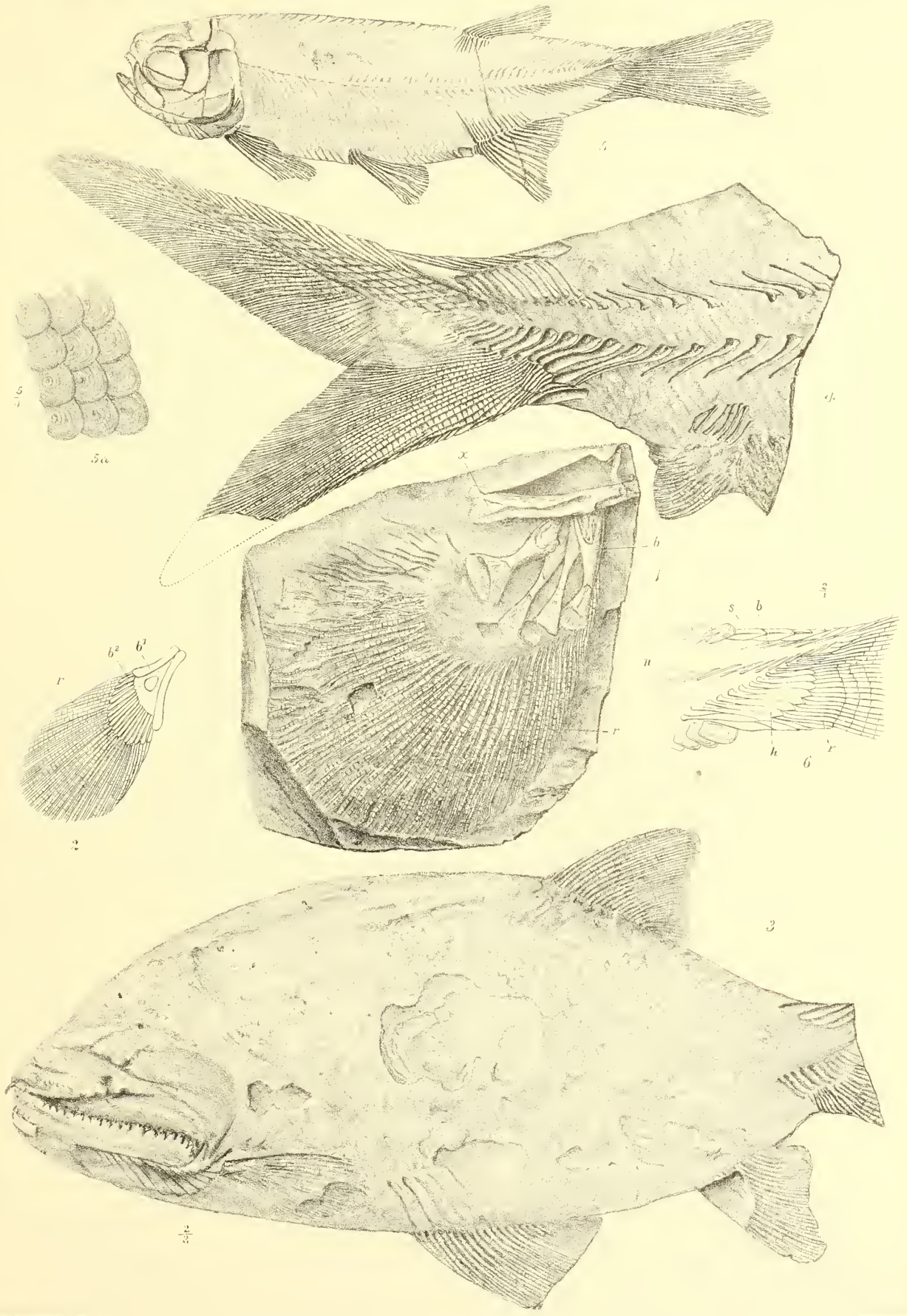
NOTE.—Unless otherwise stated, the figures are of the natural size, and all measurements in the text are given in decimal fractions of the metre.

PLATE I.



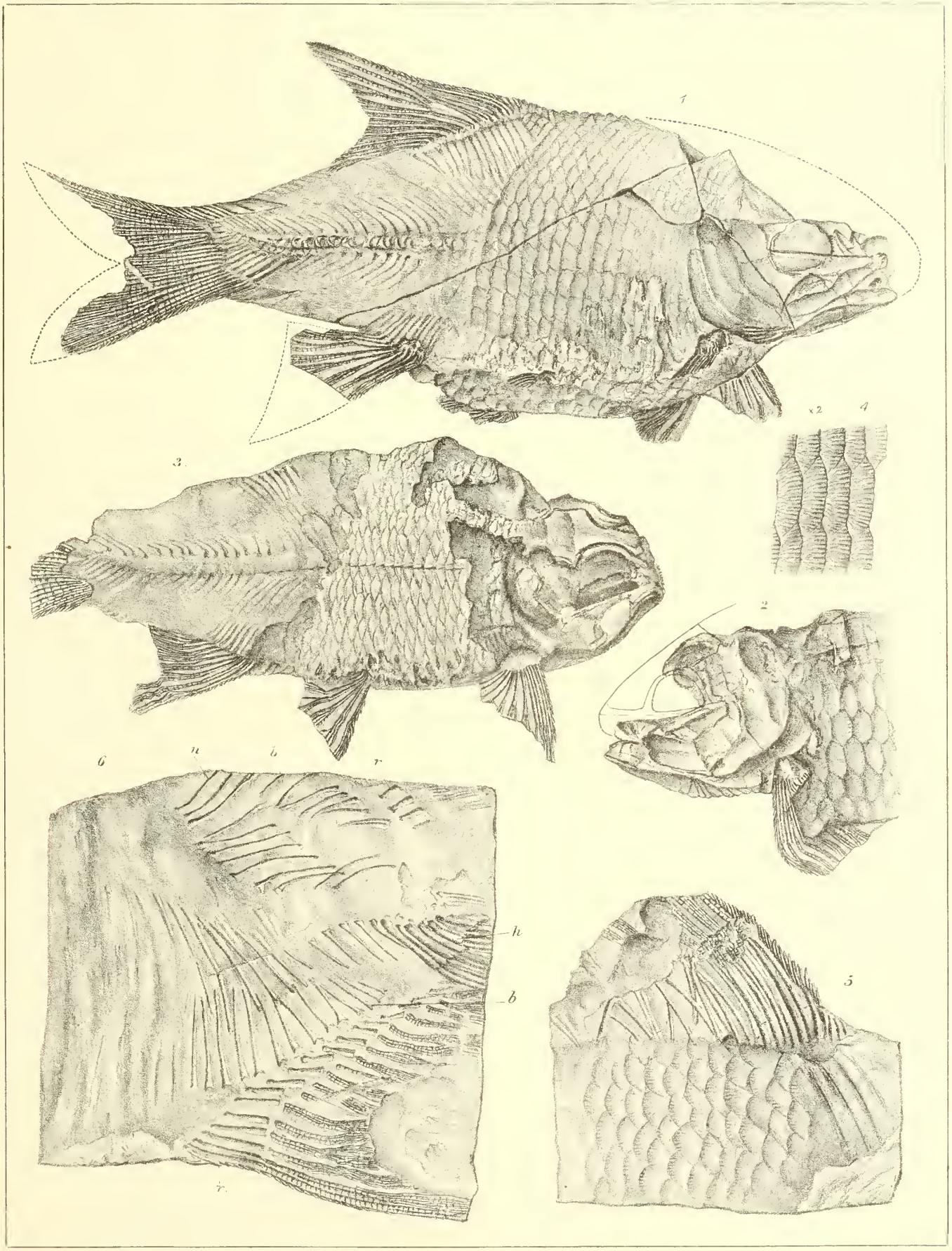
Longman & Highley, C.

PLATE II.



1. CŒLACANTH GENUS. 2. POLYPTERUS. 3.4. COCCOLEPIS.
5. 6. ARCHÆOMÆNE.

PLATE III.



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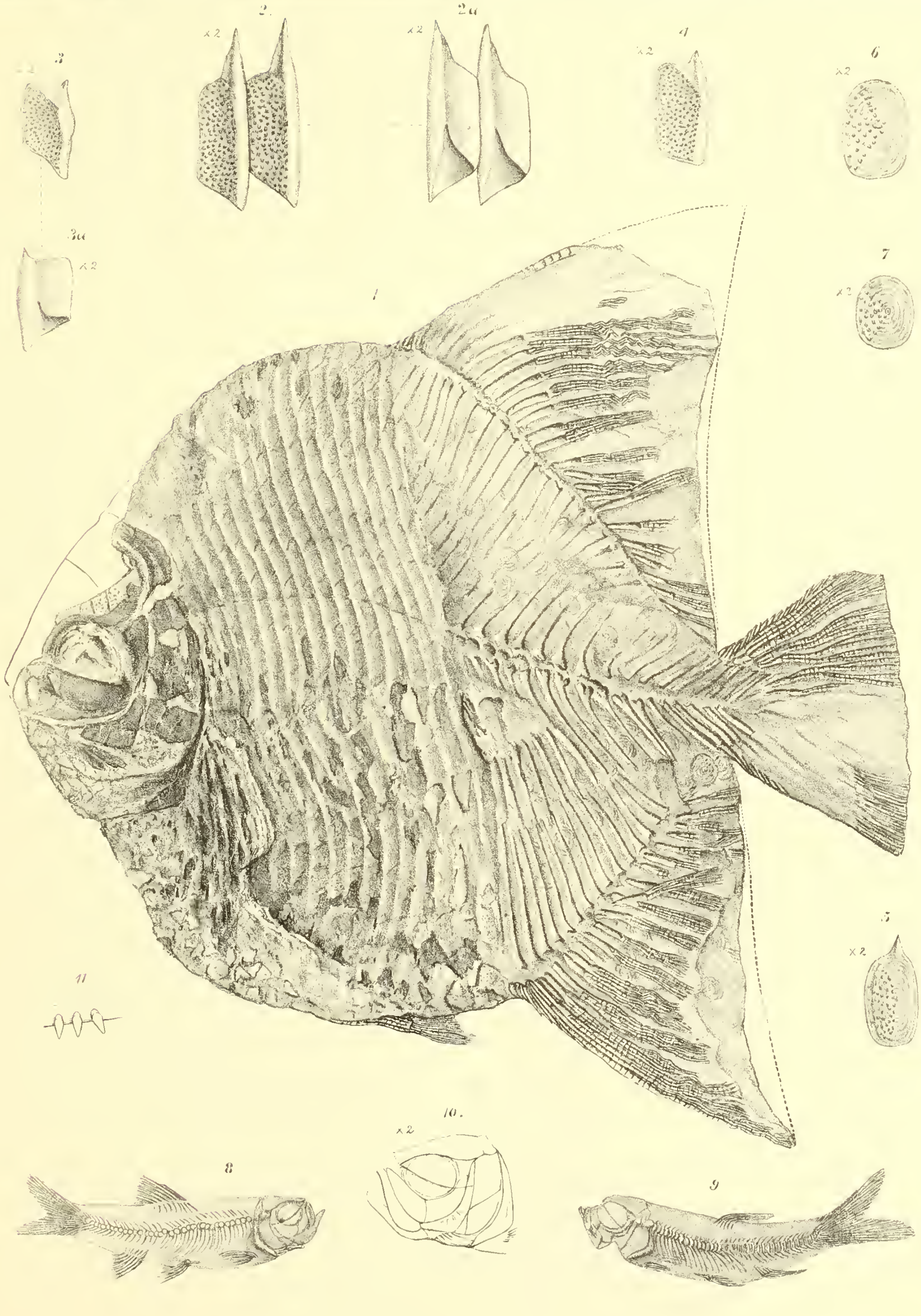
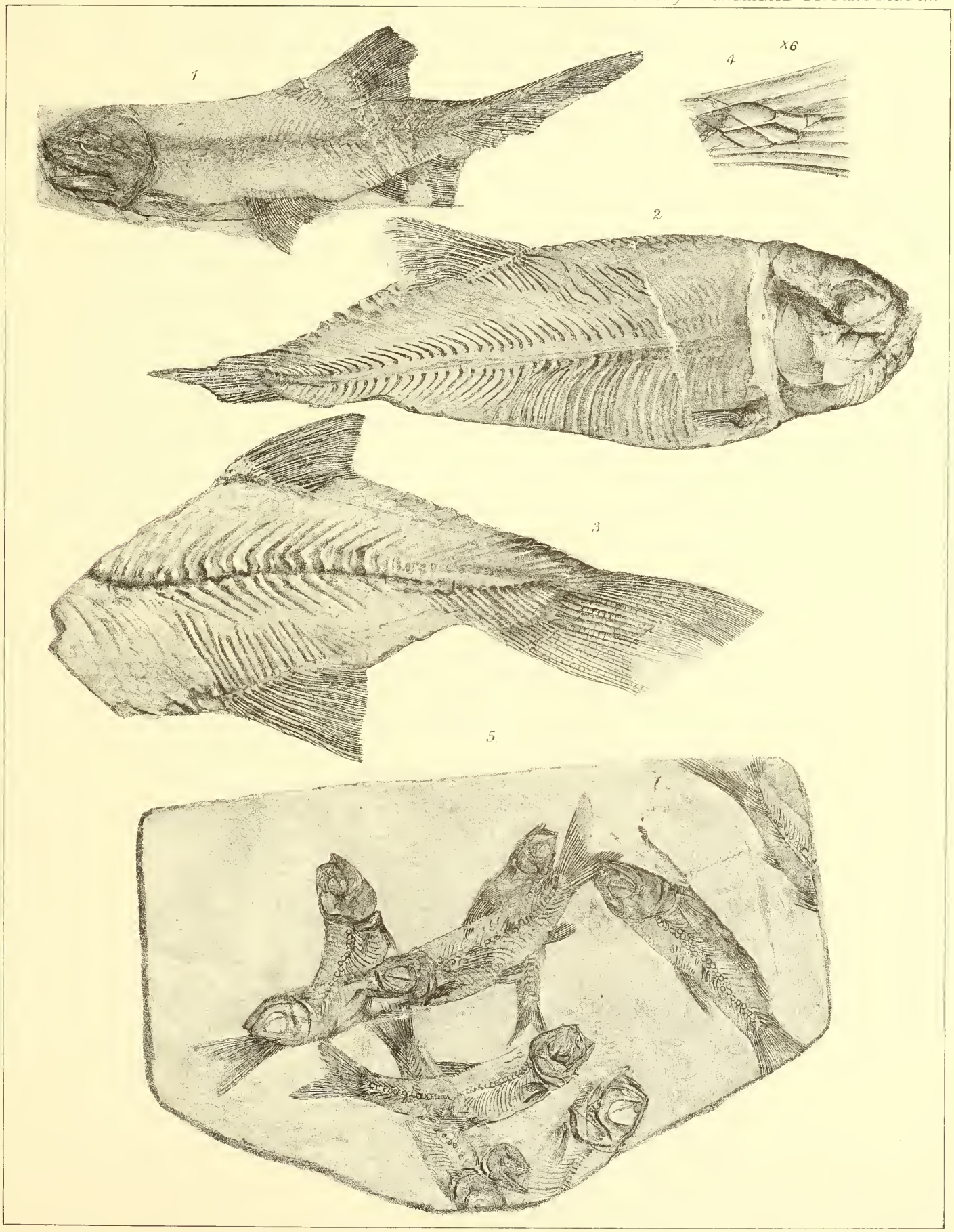
1-5. APHNELEPIS 6 AETHEOLEPIS

PLATE IV.



1-7 AETHEOLEPIS 8-11. LEPTOLEPIS

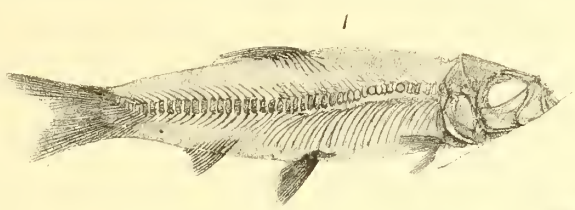
PLATE V.



Hanhart imp.

1. COCCOLEPIS. 2-4. ARCHÆOMÆNE.
5. LEPTOLEPIS.

PLATE VI.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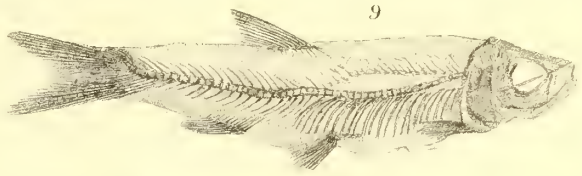
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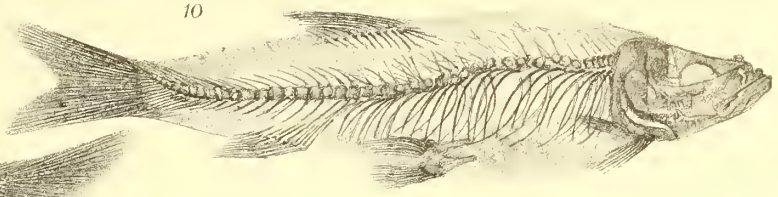
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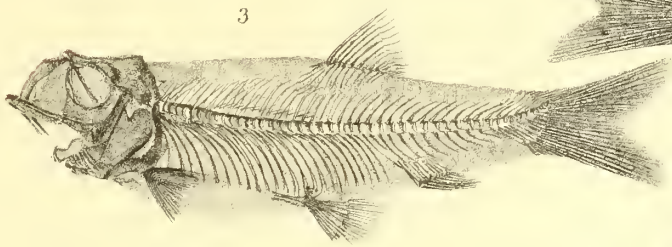
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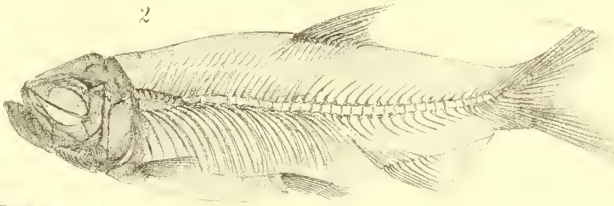
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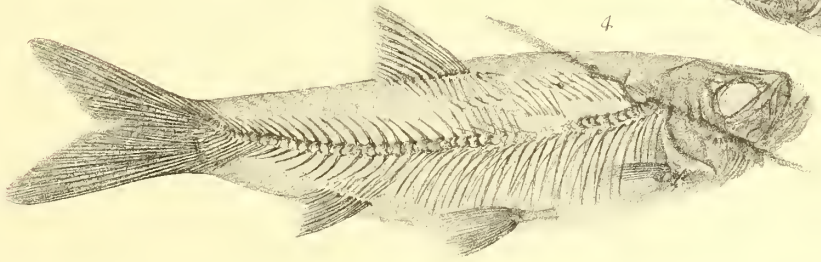
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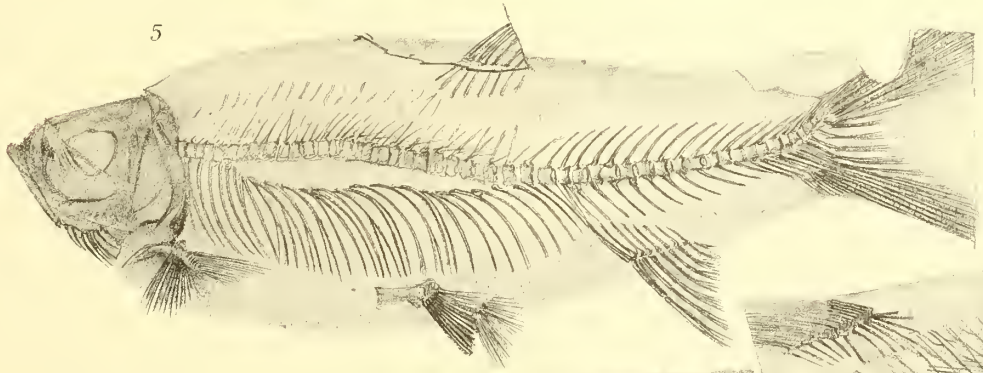
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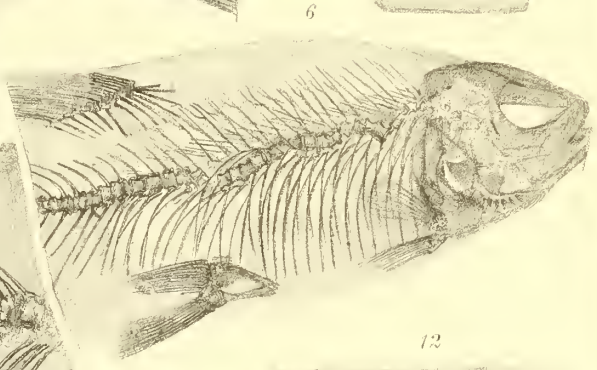
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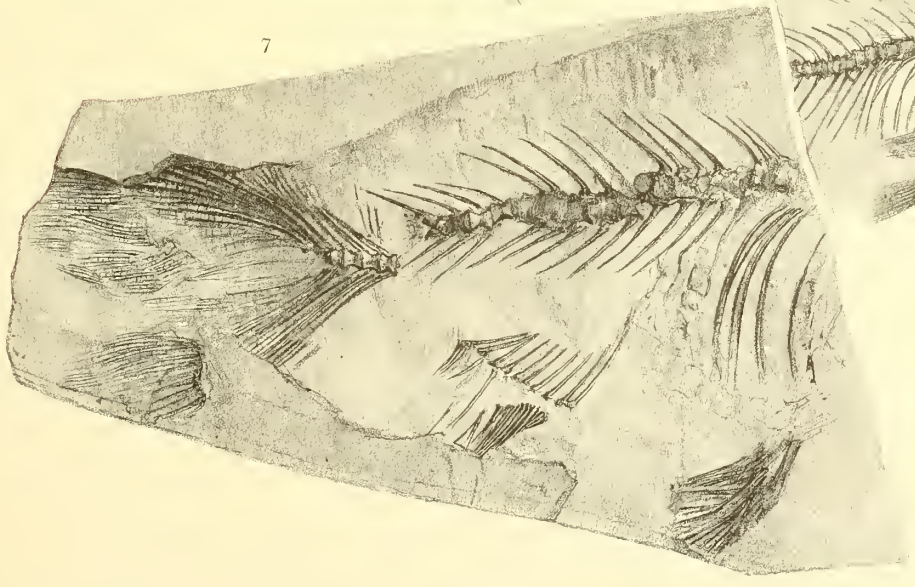
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F.H.Michael del et lith

Hanhart imp

LEPTOLEPIS.